

IMPROVE

Winter 2001

The IMPROVE Newsletter

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Monitoring update

Network operation status

The IMPROVE network operated 102 aerosol samplers, 17 transmissometers, 8 nephelometers, and 5 camera systems during the Winter 2001 monitoring season (December 2000, and January and February 2001).

Preliminary data collection statistics for the Winter 2001 season are:

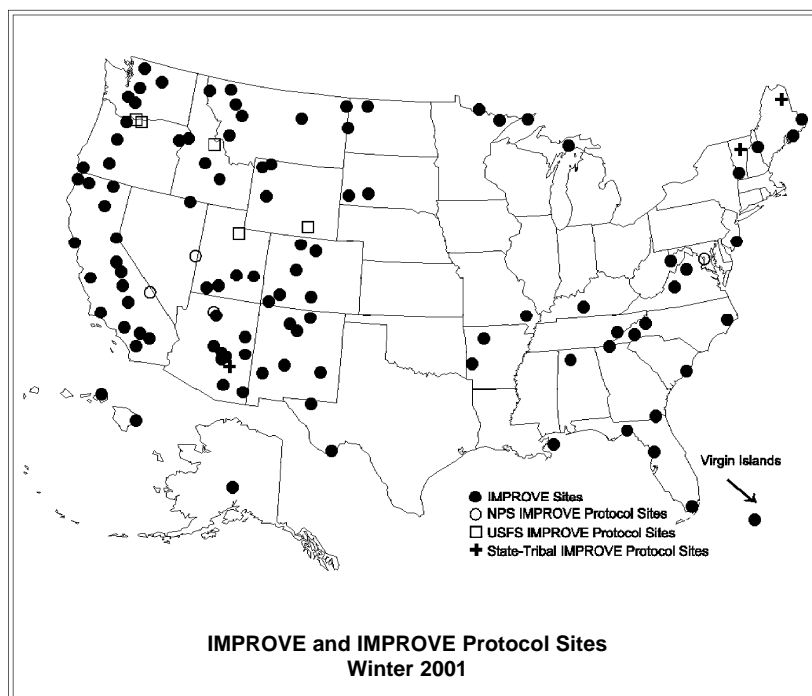
- Aerosol (channel A only) 93% collection
- Aerosol (all modules) 90% completeness
- Optical (transmissometer) 93% collection
- Optical (nephelometer) 94% collection
- Scene (photographic) 83% collection

The following monitoring sites received the Version II IMPROVE aerosol sampler during Fall 2000:

Columbia River, OR (Mt. Zion Protocol site)
 Pasayten W, WA (IMPROVE site)
 Presque Isle, ME (Protocol site)
 Proctor Research Center, VT (Protocol site)

The following IMPROVE and IMPROVE Protocol (Pro) aerosol sites are scheduled to receive a Version II sampler:

Addison-Pinnacle, NY (Pro)	MK Goddard, PA (Pro)
Arendtsville, PA (Pro)	Mohawk Mountain, CT (Pro)
Bondville, IL (Pro)	Old Town, ME (Pro)
Bridgton, ME (Pro)	Olympic NP
Cadiz, KY (Pro)	Organ Pipe, AZ (Pro)
Cape Cod NS, MA (Pro)	Quabbin Reservoir, MA (Pro)
Casco Bay, ME (Pro)	Quaker City, OH (Pro)
Connecticut Hill, NY (Pro)	Saguaro NP
Denali - Trapper Creek (Pro)	Saguaro West, AZ (Pro)
Hercules-Glades W	Sikes, LA (Pro)
Hillside, AZ (Pro)	Simeonof NWR
Hoover W	Spokane Reservation, WA (Pro)
Livonia, IN (Pro)	Tuxedni NWR
Martha's Vineyard, MA (Pro)	White Mountain W
Meadview, AZ (Pro)	Wichita Mountains



Data availability status

Aerosol data for all measurements including carbon are available through February 2000 and optical data are available through November 2000 on the IMPROVE Web site, at <http://vista.cira.colostate.edu/improve/Data/data.htm>. Aerosol data and seasonal summaries are also available on the UC-Davis Web site, at <http://improve.cnl.ucdavis.edu>.

Photographic slides are archived but are not routinely analyzed or reported. Complete photographic archives and slide spectrums (if completed) are available at Air Resource Specialists, Inc.

IMPROVE data are available to interested parties for use in presentations, management plans, and other projects. All data are validated using IMPROVE protocols, which are documented in standard operating procedures. Procedures are available for site selection; instrument installation, operation, and servicing; and data collection, reduction, validation, reporting, and archive. IMPROVE standard operating procedures are available on the IMPROVE Web site at <http://vista.cira.colostate.edu/improve/Publications/publications.htm>.

Visibility news

IMPROVE studies data quality assurance

A dozen IMPROVE data providers and analysts met for an aerosol data quality assurance workshop at the Tamasag Center in Fort Collins, Colorado, on February 5-6, 2001. Workshop attendees from the University of California-Davis (UCD), the Cooperative Institute for Research in the Atmosphere (CIRA), Air Resource Specialists, Inc., and the National Park Service discussed improving data reporting and identifying data quality issues in the database.

The group reviewed aerosol data summary plots from all sites to date, including time series and scatter plots, to identify questions and suggest methods of responding to them. Several issues were discussed in detail.

An important issue at the workshop was an observation that nitrate variability dropped around 1996 at a number of sites. This affects the analysis of trends when using the 20% of days with highest nitrate. The variability, however, did not drop at all sites, so the question remains whether the variability decrease is real or if it is an artifact of sampling or analysis. Among other discussions, the group also focused on comparisons between sulfur and sulfate, fine mass and reconstructed mass, and organic mass calculations by hydrogen and carbon. UCD and CIRA personnel received assignments on a number of issues for further analysis. The group plans to meet annually to continue quality assurance review of the data.

For more information contact Dr. Lowell Ashbaugh of UC-Davis. Telephone: 530/752-2828. Fax: 530/752-4107. E-mail: ashbaugh@crocker.ucdavis.edu.

WinHaze 2.8.0 released

WinHaze, the visual image model available as freeware, has been updated to now include 57 pre-selected images for modeling the visual effects of user-selected optical parameters or aerosol species. The images are scenes of national parks, wildernesses, and urban areas.

The 32-bit program operates under Windows 95, 98, 2000, or Windows NT 4.0. For more about the software and system requirements for download, log on to the Internet at <http://www.air-resource.com> and select *What's New*.

WinHaze is available at <ftp://ftp.air-resource.com>. Click on *Whz280_1.exe* for download.

Regional planning organizations develop in response to regional haze regulations

The Environmental Protection Agency provides funding to five regional planning organizations, led by states and tribes across the United States, to address haze and visibility from a regional perspective. The creation of these organizations, listed below, stems from the implementation of the 1999 Regional Haze Rule:

- Central States Regional Air Partnership
- Midwest Regional Planning Organization
- Ozone Transport Commission
- Southeast States Air Resource Managers
- Western Regional Air Partnership

Member states and tribes of each organization, as depicted in Figure 1, in coordination with several federal agencies and private interests, will evaluate air pollution problems in their regions, then develop strategies to reduce pollutants that cause regional haze.

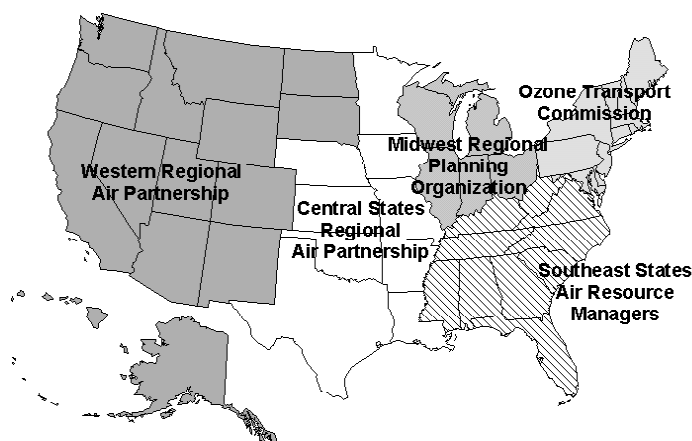


Figure 1. States and Tribes across the United States joined forces to create five regional planning organizations to address the problem of regional haze.

Each of the five regional planning organizations will be featured in upcoming *IMPROVE Newsletters*. The first of the series discusses the work of the Ozone Transport Commission, and can be found on page 6 of this issue.

For more information, visit <http://www.epa.gov/air/visibility>, or contact Marc Pitchford at the U.S. EPA. Telephone: 702/895-0432. E-mail: marcp@snsd.dri.edu.

Visibility news continued on page 6...

Feature article

Nephelometer data review results in changes to processing and validation procedures

Introduction

The Optec NGN-2 ambient nephelometer was introduced into the IMPROVE network beginning in 1993. IMPROVE protocol (or equivalent) sites have operated the NGN-2 for many years as well. As the IMPROVE contractor for optical monitoring, Air Resource Specialists, Inc. (ARS) developed software for nephelometer data collection, processing, validation, and reporting. ARS has recently completed an extensive six-month review of this software. The purpose of the review was:

- To evaluate whether existing algorithms best accomplish data processing and validation goals.
- To identify and correct past and existing errors.
- To prepare an up-to-date nephelometer data set for all IMPROVE and IMPROVE protocol sites.

Results from this review led to several global algorithm changes and site-specific corrections. This article summarizes nephelometer data processing and validation, discusses the changes and corrections resulting from the review and how they affect reported nephelometer data, and concludes with an analysis of the relative significance of the changes.

Nephelometer Data Processing and Validation

Nephelometer data pass through several stages of processing and validation. Level-0 processing is the stage associated with raw 5-minute data averages. Level-1 processing is the stage associated with final hourly data averages in engineering units. Level-1 validation also contains tests for identifying and flagging periods of particle scattering data affected by meteorological or other interference. The four Level-1 tests that are now used to identify interference are:

- Rate of change test – If the rate of change between consecutive hourly scattering values exceeds a set threshold, both values are flagged for interference.
- Standard deviation divided by the mean test – If the standard deviation divided by the mean of the valid 5-minute scattering readings which make up an hourly average exceeds a set threshold, the hourly value is flagged for interference.
- Maximum scattering test – If the hourly scattering value exceeds the set maximum threshold, the hourly value is flagged for interference.

- Relative humidity test – If the hourly relative humidity value exceeds a set threshold, the hourly scattering value is flagged for interference.

Level-1 data not flagged for interference are called “filtered.” Generally it is the filtered scattering data that are compared to reconstructed aerosol scattering estimate.

Algorithm Changes and Site-Specific Corrections

Level-0 Rate of Change Algorithm

The six-month data review resulted in processing algorithm changes. From the start of the IMPROVE optical network until mid-2000, the nephelometer, temperature, and relative humidity data underwent a 5-minute “rate of change” test as part of Level-0 validation. If the rate of change between two consecutive 5-minute data points was greater than a set thresholds for each parameter, both data points were flagged as invalid and were not used in later calculation of the hourly average. The thresholds used were:

- Absolute change in 5-minute nephelometer raw counts > 100
- Absolute change in 5-minute ambient temperature > 5 °C
- Absolute change in 5-minute chamber temperature > 5 °C
- Absolute change in 5-minute relative humidity > 5%

ARS has eliminated the Level-0 (5-minute) rate of change test and now relies on the Level-1 hourly average rate of change and standard deviation test of hourly data to identify hours of highly fluctuating data. The inclusion of previously invalidated 5-minute data points in an hourly average can:

- Increase or decrease the average hourly nephelometer count value, and thus the calculated scattering value.
- Increase or decrease the standard deviation of the hourly nephelometer count value.
- Change the results of the Level-1 “rate of change,” “standard deviation divided by the mean,” and “maximum threshold” tests on hourly scattering data for optical interference.
- Allow for additional hourly scattering data points which were previously considered invalid.

- Increase or decrease the average hourly relative humidity values, which may change the results of the Level-1 “relative humidity” test on scattering data for optical interference.
- Increase or decrease the average hourly temperature values.

Serial/Analog Data Algorithm

Nephelometer data are output in serial and analog format. Serial data are considered primary, and analog data (if available) are used to fill gaps of missing serial data. Since mid-1995 periods of missing serial data have been consistently replaced by analog data. Before mid-1995 this algorithm did not work properly and periods of missing serial data were flagged as missing, even though valid analog data might have been available. The latest data release corrects this problem with early network data. The substitution of valid 5-minute analog data points in an hourly average can:

- Increase or decrease the average hourly nephelometer count value, and thus the calculated scattering value.
- Allow for an hourly count value which was previously missing, and thus add an additional scattering value to the data set.
- Change the results of the Level-1 “rate of change,” “standard deviation over the mean,” and “maximum threshold” tests on hourly scattering data for optical interference.

Validation of Zero Calibrations

Validation of zero calibrations is important to the scattering calculation because each hourly scattering value uses an effective zero value determined by a linear interpolation between the previous valid zero and the next valid zero. Zero calibrations are routinely separated from the raw data upon collection and are appended to an instrument-specific and run-specific quality assurance (QA) file. (A new QA file for a specific site is initiated when the nephelometer is replaced or there is a significant change in the operation of the existing instrument.) The Level-1 validation algorithm for zero calibrations begins at the start of each QA file and divides the data into consecutive 30-day windows for analysis. Zero calibrations are flagged as invalid if they:

- Deviate from the mean of the zeros in the window by more than a set threshold.
- Deviate from the best fit line of the zeros in the window by more than a set threshold.
- Are higher or lower than the maximum or minimum allowed zero.

Until mid-2000, data processing software arbitrarily ended the 30-day windows at midnight on the final day of each window. This resulted in initial windows being too short, and subsequent windows shifting slightly with time. This algorithm has been modified to fit exactly 30 days to the windows. The correction can affect the validity of zero calibrations and ultimately the hourly scattering values by:

- Changing the mean of the zero calibrations over the window, potentially changing the validity status of specific zero calibrations.
- Changing the best fit line of the zero calibrations over the window, possibly changing the validity status of specific zero calibrations.
- Increasing or decreasing scattering values during periods where the effective zero has decreased.

Data Translation Rounding

Beginning with the Fall 1997 season, ARS made the following changes to Level-1 nephelometer data files:

- Total scattering (b_{scat}) was replaced with particle scattering (b_{sp}). The two are related by: $b_{\text{sp}} = b_{\text{scat}} - b_{\text{Rayleigh}}$.
- Scattering units were changed from km^{-1} to Mm^{-1} .
- Validity/interference codes were revised.
- The data format was revised to include a 4-digit year.

Level-1 files containing data prior to Fall 1997 were “translated” from the old to the new format. The translation algorithm introduced rounding errors and the translated b_{sp} data at all sites were often found to have changed by $\pm 1 \text{ Mm}^{-1}$.

Incorrect Rayleigh Scattering

Correct processing of scattering data requires the use of a site-specific Rayleigh scattering value (b_{Rayleigh}), which can range from $8\text{--}12 \text{ Mm}^{-1}$. Data from some sites during some seasons were inadvertently processed using 10 Mm^{-1} instead of the site-specific values. An increase/decrease in b_{Rayleigh} at a site will increase/decrease calculated b_{sp} values.

Reassessment of Calibration Data

As noted above, calibration data are collected and appended to an instrument/site-specific QA file and validated during Level-1 validation. Occasionally, calibration or instrument diagnostic information received after data have been reported will require a reassessment of calibration data validity. A change in calibration data validity will change calculated b_{sp} values for a specific time period.

Use of a Manual Interference Flag

As noted above, Level-1 processing contains algorithms for automatically flagging b_{sp} data as affected by interference (e.g., rain, fog, snow). During 1995 ARS introduced an algorithm change to allow manual interference flags on b_{sp} data. This change was short-lived, but some of the interference flags from that time exist in previously published data. While manual interference flags are no longer used, data from many sites in 1995 contained these flags.

Site-specific Data Corrections

Nephelometer data from the Gila site from Summer 1994 through Spring 1995 were affected by a torn pump diaphragm in the nephelometer calibration system. The original data set for this period contained artificially low b_{sp} values. All invalid zero calibrations from that period were replaced by a set of corrected zero values based on reconciling clean day 24-hr average nephelometer data with 24-hr average reconstructed aerosol scattering data.

Originally reported data from the Dolly Sods site from Spring through Summer 1993 was incorrect. It is believed that an error in the data collection or processing programs at that time placed data from another site into the Dolly Sods data file. Raw data from those seasons have been used to generate the most current files.

Analysis of Algorithm Changes

To determine the significance of each algorithm change and site-specific correction, ARS attempted to separate the effect of each individual change and investigate its frequency and magnitude. The complete IMPROVE and IMPROVE protocol (or equivalent) nephelometer database consists of approximately 1.2 million previously published hourly averages of ambient particle scattering. Twenty-four percent of these hourly averages changed with the recent reprocessing, and nearly half of those consisted of the small error ($\pm 1 \text{ Mm}^{-1}$) associated with the data translation rounding. Table 1 summarizes the contribution for each change. (Note that since it was not always possible to separate errors, the percentages given are only approximate.)

ARS also calculated the standard seasonal parameters (visibility metric and cumulative frequency values) for each site-season. Figure 1 illustrates the relatively small effect these changes have on most filtered seasonal means. The dots on the scatterplot represent the previously published and newly reprocessed seasonal means for 580 site-seasons at IMPROVE and protocol sites operational between 1993 and 2000. The most significant outliers include seasons affected by the manual interference flag and incorrect Rayleigh scattering.

Table 1. Analysis of Algorithm Changes and Site-Specific Corrections

Algorithm/Error	% of Total Nephelometer Hours	Effect
Level-0 Rate of Change Algorithm	8.0	Significant, especially for sites with high scattering and/or high humidity.
Serial/Analog Data Algorithm	0.8	Minor
Validation of Zero Calibrations	0.2	Minor
Data Translation Rounding	11.7	Minor ($\pm 1 \text{ Mm}^{-1}$)
Incorrect Rayleigh Scattering	2.6	Significant for affected sites
Reassessment of Calibration Data	0.1	Minor
Use of a Manual Interference Flag	0.1	Minor effect overall, though significant at a few sites
Site-specific Data Corrections	0.5	Significant for affected sites
Total	24.0	All algorithm changes and site-specific corrections affected approximately 24% of all nephelometer scattering hours

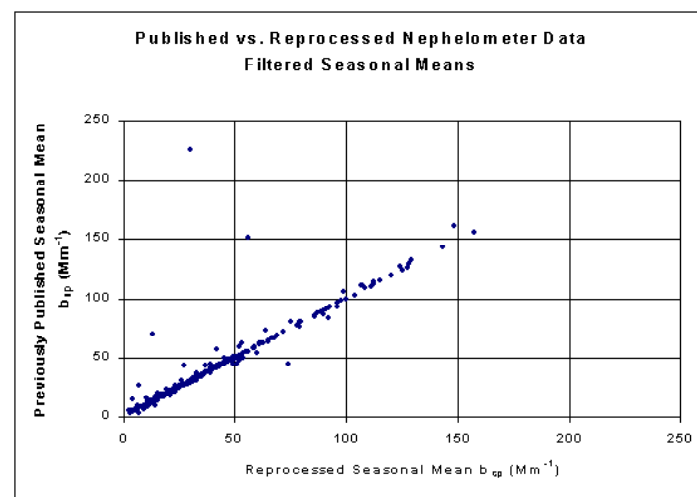


Figure 1. Scatterplot of seasonal means for IMPROVE and IMPROVE protocol sites; 1993 - 2000.

Data Release

ARS has released all newly reprocessed nephelometer data. All optical data are available on the IMPROVE Web site, at <http://vista.cira.colostate.edu/improve/Data/data.htm>.

For more information regarding nephelometer data processing and validation review, contact Joe Adlhoch at ARS. Telephone: 970/484-7941. Fax: 970/484-3423. E-mail: Jadlhoch@air-resource.com.

Visibility news *continued from page 2*

Regional planning organizations Part I: Ozone Transport Commission (Mid-Atlantic and Northeast region)

Overview

In response to EPA's regional haze regulations of 1999, the Ozone Transport Commission (OTC) was selected to coordinate the development of one of the five regional planning organizations (RPOs) in the country to address visibility concerns in the Mid-Atlantic and Northeast region.

The RPO for the Mid-Atlantic and Northeast region includes Washington D.C., Maryland, Delaware, Pennsylvania, New Jersey, New York, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, Maine, and interested Tribes. The EPA and federal land managers are non-voting participants. The region includes seven Class I areas:

- Acadia National Park, Maine
- Brigantine Wilderness, New Jersey
- Great Gulf Wilderness, New Hampshire
- Lye Brook Wilderness, Vermont
- Moosehorn Wilderness, Maine
- Presidential Range - Dry River Wilderness, New Hampshire
- Roosevelt Campobello International Park, New Brunswick

Partners in laying the groundwork for the OTC include the Northeast States for Coordinated Air Use Management (NESCAUM) and the Mid-Atlantic Regional Air Management Association (MARAMA), which are IMPROVE members. These organizations will compile and report data, support research, and coordinate the development of solutions.

Recent Progress

In January 2001, the OTC released an introductory, yet comprehensive report regarding visibility impairment and regional haze in the OTC region. The report, *Regional Haze and Visibility in the Northeast and Mid-Atlantic States*, was prepared by NESCAUM and is available on NESCAUM's Web site at <http://www.nescaum.org> and on the Ozone Transport Commission's Web site at <http://www.sso.org/otc>. The OTC and its partners recognize that the nature of regional haze must first be understood before solutions to the problem are posed, hence the report presents a basic overview of the

haze problem and explores the nature and extent of visibility impairment in the Mid-Atlantic and Northeast regions. The report also discusses federal regional haze requirements, building a regional haze plan, haze-associated pollutants, analytical tools, visibility monitoring, and social and economic considerations. Among the significant findings of the report, is that sulfates are a major contributor to visibility impairment in the Mid-Atlantic and Northeast regions. Airborne particulates that contribute to the haze problem also contribute to acid deposition and eutrophication of waterways, and cause public health problems including respiratory illness.

Future Work and Recommendations

The January 2001 report collected information related to haze issues that require further research prior to development of the State Implementation Plans needed for the regional haze regulation. Six recommendations were made:

- Basic science: the character of natural background and baseline conditions needs to be refined, and secondary aerosols and the contribution of human-made sources needs further study.
- Modeling and Data Analysis: a regional modeling strategy needs to be developed, differences in source contributions need assessment, and geographic information systems should be used to map and display data.
- Air Quality Monitoring and Measurement: methods for dealing with incomplete data need to be developed, particle mass data need re-sorting, PM_{2.5} data need compiling, updating, and evaluating, marine aerosols need quantifying, and the CAMNET photographic program should be expanded.
- Emissions Inventories: inventories for ammonia need to be developed, inventories for volatile organic compounds (VOCs), SO₂, and PM_{2.5} need to be improved, and the visibility benefits of motor vehicle emission reductions needs evaluation.
- Communication / Education: education programs for the public, policymakers, and affected industry need to be developed.
- Regulation Efforts: a technical analysis of the Regional Haze Rule's BART provisions needs to be performed to identify potential emission reduction opportunities.

More on Emissions Inventories

Another report, whose preparation was spearheaded by MARAMA and released in March 2001, focuses on emissions inventory needs (see <http://www.marama.org>). The report notes that EPA's existing National Emissions Inventory provides good sulfur dioxide, VOCs, and nitrogen oxide emissions data for major sources. A great deal of uncertainty exists, however, in current emissions inventories for ammonia and non-VOC organics. Furthermore, the fine particle emissions inventory for most states has not undergone the extensive review and quality assurance that will be needed before developing emissions control programs.

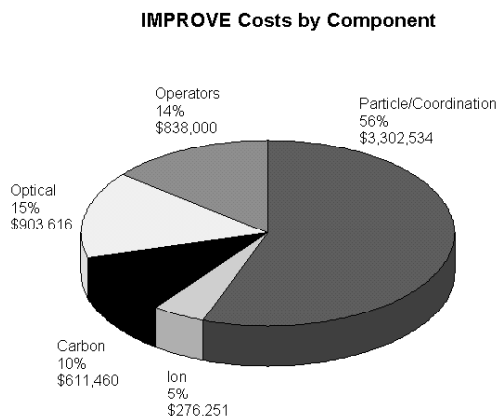
Regional Cooperation

Under the regional haze regulations, States (and potentially Tribes) will need to submit implementation plans to the EPA over the next several years. The OTC and its partners are coordinating further research to better understand the nature and causes of visibility problems in the region. While doing so, OTC is coordinating the organization of the regional framework to develop and implement solutions.

For more information, contact the Ozone Transport Commission at the Hall of the States; 444 North Capitol St., Suite 638; Washington, DC 20001. Telephone: 202/508-3840. Fax: 202/508-3841.

FY2001 IMPROVE program budget

The graphic below shows anticipated funding distributions for operating the IMPROVE Program during Fiscal Year 2001. The total budget for the year is \$5,931,861.



For more information contact Dave Maxwell at the National Park Service Air Resources Division. Telephone: 303/969-2810. Fax: 303/969-2822. E-mail: david_maxwell@nps.gov.

USFWS and NPS sponsor regional haze workshop

The U. S. Fish and Wildlife (USFWS), Air Quality Branch and National Park Service, Air Resources Division sponsored a regional haze workshop at the USFWS National Conservation Training Center in Shepherdstown, WV, on February 21-22, 2001. A total of 46 representatives from the USFWS, National Park Service, and USDA Forest Service attended from all regions of the U. S., including Alaska and Hawaii.

The main objective of the workshop was to bring the headquarters, field, and regional staff together to plan how to most effectively aid in implementing the Regional Haze Rule. The workshop provided information on air quality, monitoring, and the Clean Air Act. It focused on the Regional Haze Rule to improve understanding of the new rule and to explain the options available to federal land managers at the refuge, park, and forest level. The Regional Haze Rule, issued by EPA in April 1999, allows federal land managers to directly influence future visibility and other air quality related values at our refuges, parks, and forests. States must conduct certain analyses to ensure that they consider the possibility of reaching natural background conditions in 60 years, and the rate of improvement during each 10- to 15-year planning period is expected to be consistent with that glidepath (unless the state can justify a deviation). The states, federal land managers, and EPA will use data from the IMPROVE network to measure progress and set the goals for the long-term strategies.

Workshop participants left the course with an understanding of how regional haze affects refuge, forest, and park resources, the applicable regulations, and the planning process being used to implement the new regulations. They helped to begin the development of a shared approach for addressing key issues that will be presented during the planning process. They also learned about the types of technical information and assistance that are available or may be needed. Participants commented that "this was a good introductory course to the haze problem," that "it was relevant to the IMPROVE site I operate," and was "well organized and facilitated networking across the nation."

For more information, contact Kirsten King of the U.S. Fish and Wildlife Service. Telephone: 303/969-2153. Fax: 303/969-2822. E-mail: Kirsten_King@nps.gov.

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IMPROVE Steering Committee members represent their respective agencies and meet periodically to establish and evaluate program goals and actions. IMPROVE-related questions within agencies should be directed to the agency's Steering Committee representative. Steering Committee representatives are:

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Associate Membership in the IMPROVE Steering Committee is designed to foster additional IMPROVE-comparable visibility monitoring that will aid in understanding Class I area visibility, without upsetting the balance of organizational interests obtained by the steering committee participants. Associate Member representatives are:

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Government organizations
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contact any Steering Committee
member for information.

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in response to the visibility provisions
of the Clean Air Act of 1977, which
affords visibility protection to 156
federal Class I areas. The program
objectives are to provide data needed
to: assess the impacts of new emission
sources, identify existing human-made
visibility impairments, and assess
progress toward the national visibility
goals as established by Congress.

To submit an article, to receive the
IMPROVE Newsletter, or for address
corrections, contact:

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the National Park Service Web site at:
[http://www.aqd.nps.gov/ard/impr/
index.htm](http://www.aqd.nps.gov/ard/impr/index.htm)

